Open Research Journal of Science and Environment
Vol. 1, No. 1, November 2013, PP: 27 -42
Available online at http://scitecpub.com/Journals.php

Research article

MODELING FLOW NET OF VIRUS AND IONIC CONTENT MIGRATION INFLUENCED BY DEGREE OF SATURATION AND VOID RATIO IN HOMOGENEOUS FINE SAND FORMATION IN YENAGOA METROPOLIS NIGER DELTA OF NIGERIA

Eluozo, S. N[1] and Afiibor, B.B[2]

[1]Subaka Nigeria Limited, Port Harcourt, Rivers State of Nigeria
Director & Principal Consultant, Civil & Environmental Engineering,
Research & Development
E-mail: Soloeluozo2013@hotmail.com
E-mail: solomoneluozo2000@yahoo.com

[2]Department of Mathematics and Computer Science
Rivers State University of Science and Technology, Nkpolu, Port Harcourt
E-mail: afiibor4bony@yahoo.com

Abstract

Modeling the deposition of ionic content and virus were carried to express their Physiochemical reaction in the system. The study was to monitor the level of concentration at different formation; such conditions were found from hydrogeological studies carried out in the study location. The deposition and migration of virus and ionic content are influenced by formation characteristics such as degree of saturation from high rain intensities and high percentage of void ratio, these two influential parameters were expressed in the system, the derived solution from the governing equation developed a model that will monitor the deposition of ionic content and virus in penetrating unconfined bed.

Keywords: modeling ionic content, virus, degree of saturation and homogeneous fine sand

1. Introduction

Copyright © scitecpub.com, all rights reserved.

Metals contamination is a persistent problem at many contaminated sites. In the U.S., the most commonly occurring Metals at Superfund sites are lead, chromium, arsenic, zinc cadmium, copper, and mercury. The presence of metals in groundwater and soils can pose a significant threat to human health and ecological systems. The chemical form of the metal contaminant influences its solubility, mobility, and toxicity in ground-water systems. The chemical form of metals depends on the source of the metal waste and the soil and ground -water chemistry at the site. A detailed site characterization must be performed to assess the type and level of metals present and allow evaluation of remedial alternatives. A number of the available technologies have been demonstrated in full-scale applications and are presently commercially available. A comprehensive list of these technologies is available (U.S. EPA, 1996a). Several other technologies are being tested for application to metals-contaminated sites Treatment of metals contaminated groundwater has typically involved flushing and aboveground treatment, while treatment of contaminated solids most often has been performed by excavation followed by ex situ treatment or disposal. The most common ex situ treatment for excavated soils is solidification/stabilization. Soil consists of a mixture of weathered minerals and varying amounts of organic matter. Soils can be contaminated as a result of spills or direct contact with contaminated waste streams such as airborne emissions, process solid wastes, sludges, or leachate from waste materials. The solubility of metals in soil is influenced by the chemistry of the soil and ground water (Sposito, 1989; Evans, 1989). Factors such as pH, Eh, ion exchange capacity, and complexation/chelation with organic matter directly affect metal solubility. Surface water and groundwater may be contaminated with metals from wastewater discharges or by direct contact with metals-contaminated soils, sludge's, mining wastes, and debris. Metal-bearing solids at contaminated sites can originate from a wide variety of sources in the form of airborne emissions, process solid wastes, sludges or spills. The contaminant sources influence the heterogeneity of contaminated sites on a macroscopic and microscopic scale. Variations in contaminant concentration and matrix influence the risks associated with metal contamination and treatment options. Most published research reports have been focused on bioreduction of U(VI) by various microbial cultures at laboratory scale (e.g., Lovley et al., 1991; Lovley and Phillips, 1992a,b; Gorby and Lovley, 1992; Ganesh et al., 1997; Truex et al., 1997; Abdelouas et al., 1998; Fredrickson et al., 2000; Fredrickson et al., 2002; Holmes et al., (2002). Kinetics have been analyzed for defined or mixed cultures in laboratory (e.g., Liger et al., 1999; Spear et al., 1999, 2000). Under field conditions, U(VI) undergoes hydrological, geochemical, and biological processes in complex interaction, such as sorption/desorption, advective-dispersive transport, and microbial transformations. Uranium sorption/desorption is significantly influenced by bicarbonate concentrations and pH (Waite et al., 1994; Wazne et al., 2003). At the sorption sites, uranium competes with other ions. Since the geochemical environment may vary over the course of the experiment, simplified approaches to model U(VI) sorption, such as the assumption of a linear retardation factor, appear insufficient (Bain et al., 2001). For bioreduction of U(VI), nitrate, Fe (III) and sulfate serve as competing electron acceptors which should be considered in the simulations (e.g., Wielinga et al., 2000; North et al., 2004; Wu et al., 2005). In the presence of significant calcium concentrations, the highly stable but poorly biodegradable calcium–

Copyright © scitecpub.com, all rights reserved.

uranyl– carbonate complexes should also be included in the simulation (Bernhard et al., 1996; Kalmykov and Choppin, 2000; Bernhard et al., 2001; Brooks et al., 2003).

2. Theoretical background

Yenagoa metropolis is deposited in the Niger Delta environment that has a lot of pollution challenges from manmade activities and natural origins. These factors have developed lots of soil and water pollution in the study location. Such deltaic influence from manmade activities cannot be overemphasized because of the negative impact it has on human settlement. Based on these challenges pointed out, it is imperative to evaluate one of the challenging pollutants on humans in the study area. Ionic content has been found to develop high percentage in Yenagoa metropolis. Generation of this contaminant is confirmed through hydrogeological studies to have deposited in fine sand formation, which is known to penetrate unconfined beds. The structure strata, no doubt is a replica of geological setting of Yenagoa depositing in penetrating unconfined bed, these are attributed to formation characteristics investigated to develop higher percentage among others, these condition influence ionic content and virus in the study area. The combination of this contaminant were confirmed through some hydrological studies as earlier stated, while the formation characteristics were evaluated from standard laboratory experiments using insitu method of sample collection. The analyses developed these results but could not produce permanent solution that can prevent pollution transport of ionic content and migration of virus in the study location. Although, it has been confirmed from other experts that ionic content deposits more through natural origin from geologic history of Yenagoa, Bayelsa State. The migration of virus depositing in fine sand formation integrated with ionic content to develop some physiochemical reactions, which will be determine the rate of concentration and migration of the microbes. Focusing the study, physiochemical reactions of these two parameters is to investigate the rate of concentration on their migration process penetrating unconfined bed. Subject to this relation, the structural setting are influenced by deltaic nature of the strata. Consequently, developing a better solution will be applied as a baseline in preventing ionic content and deposition of virus in fine sand formation penetrating unconfined beds are observed. Formulation of a system is imperative because this development generated a governing equation to monitor the deposition of ionic content and virus in penetrating unconfined beds.

3. Governing Equation

$$K\frac{\partial v}{\partial x} - \phi\frac{\partial^2 v}{\partial x^2} - V\frac{\partial v}{\partial x} = \theta\frac{\partial v}{\partial t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (1)$$

Nomenclature

v = Mass Rate of Transport [LT^{-1}]
= Dispersion coefficient in longitudinal location (MT^{-1})
V = Velocity [-]
T = Time [T]

Copyright © scitecpub.com, all rights reserved.

X = Distance [M]
K = Permeability [-]

The governing equation expressed above was formulated through a system from all variables that influenced the deposition and migration of ionic and virus in penetrating unconfined beds. Different mathematical approaches will be applied to derive the model.

$$V\frac{\partial^2 v}{\partial t}-\phi\frac{\partial \;\; V}{\partial x} \qquad \cdots\cdots\cdots\cdots \qquad (2)$$

$t = 0$

$$\left.\begin{array}{l} x = 0 \\ C_{(o)} = 0 \\ \left.\dfrac{\partial v}{\partial t}\right|_{t = 0, B} = 0 \end{array}\right\} \qquad \cdots\cdots\cdots\cdots \qquad (3)$$

$$V\frac{\partial v}{\partial t}-Q\frac{\partial v^2}{\partial x^2} \qquad \cdots\cdots\cdots\cdots \qquad (4)$$

$$\left.\begin{array}{l} t = 0 \\ x = 0 \\ q_{(o)} = 0 \\ \left.\dfrac{\partial q}{\partial t}\right|_{t = 0, \; B} \end{array}\right\} \qquad \cdots\cdots\cdots\cdots \qquad (5)$$

$$V\frac{\partial v}{\partial t}-=\theta\frac{\partial v}{\partial t} \qquad \cdots\cdots\cdots\cdots \qquad (6)$$

$$\left.\begin{array}{l} t = 0 \\ C_{(o)} = 0 \end{array}\right\} \qquad \cdots\cdots\cdots\cdots \qquad (7)$$

$$\left.\frac{\partial v_3}{\partial t}\right|_{t = 0, \; B} = 0$$

$$Q\frac{\partial v_4}{\partial x} \; -=\theta\frac{\partial v}{\partial t} \qquad \cdots\cdots\cdots\cdots \qquad (8)$$

$x = 0$

$t = 0$

Copyright © scitecpub.com, all rights reserved.

$$C_{(o)} = 0 \tag{9}$$

$$\left.\frac{\partial v_4}{\partial x}\right|_{x = 0,\ B} = 0$$

$$\phi \frac{\partial^2 v_5}{\partial x^2} - Q \frac{\partial v_5}{\partial x} \tag{10}$$

$x = 0$

$$q_{(o)} = 0 \tag{11}$$

$$\left.\frac{\partial v_5}{\partial x}\right|_{x = 0,\ B}$$

Applying direct integration on (2)

$$V \frac{\partial v_1}{\partial t} = \phi v + K_1 \tag{12}$$

Again, integrate equation (12) directly yield

$$Vv = \phi vt + Kt + K_2 \tag{13}$$

Subject to equation (3), we have

$$Vv_o = K_2 \tag{14}$$

And subjecting equation (12) to (3) we have

$$\text{At } \left.\frac{\partial v_1}{\partial x}\right|_{t = 0} = 0 \quad v(o) = vo$$

Yield

$$0 = \phi v + K_2$$

$$\Rightarrow V_1 = \phi v_o = K_2 \tag{15}$$

So that we put (13) and (14) into (13), we have

$$Vv_1 = \phi v_{1t} - \phi vox\, Vvo \tag{16}$$

$$Vv_1 - \phi v_{1x} = Vv_o - \phi vox \tag{17}$$

$$v_1 = v_o \tag{18}$$

Hence equation (18) entails that at any given distance *x*, we have constant concentration of the contaminant in the system.

The expressions at (18) are based on homogeneous conditions of the formation, which may influence the migration concentration of the contaminants developing constant concentration in the system. It implies that the formation

Copyright © scitecpub.com, all rights reserved.

characteristics such as degree of saturation may develop constant high rain intensities generating a constant flow net. In other words, degree of void ratio is bound to express in stratification constant void ratio. Similarly, both parameters are integrated to formulate a homogeneous concentration setting in the fluid flow net on the formation as it is mathematically expressed above in equation (18).

$$V\frac{\partial v_2}{\partial v} = -Q\frac{\partial v}{\partial x} \qquad \ldots\ldots\ldots\ldots\ldots \qquad (4)$$

We approach the system, by using the Bernoulli's method of separation of variables

$$v_2 = XT \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (19)$$

i.e.

$$V\frac{\partial v_2}{\partial x} = X^1T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (20)$$

$$V\frac{\partial_2}{\partial x} = X^1T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (21)$$

Put (20) and (21) into (19), so that we have

$$VXT^1 = -QX^1T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (22)$$

$$\text{i.e. } V\frac{X^1}{X} = Q\frac{X^1}{X} = -\lambda^2 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (23)$$

$$\text{Hence } \quad V\frac{T^1}{T} + \lambda^2 = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (24)$$

i.e.

$$X^1 + \frac{\lambda}{V}x = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (25)$$

$$VX^1 + \lambda^2 X = 0 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (26)$$

$$\text{From (25), } X = A\,Cos\frac{\lambda}{V}X + B\,Sin\frac{\lambda}{\sqrt{V}}X \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (27)$$

And (20) gives

$$T = C\,\ell^{\frac{-\lambda^2}{V}t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (28)$$

And (20) gives

$$\boxed{C_2 = \left(A\,Cos\frac{\lambda}{V}x + B\,Sin\frac{\lambda}{\sqrt{V}}x\right)C\,\ell^{\frac{-\lambda^2}{V}x}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (29)$$

Copyright © scitecpub.com, all rights reserved.

Subject to equation (29) to conditions in (5), so that we have

$$V_o = AC \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (30)$$

Equation (30) becomes

$$v_2 = v_o \, \ell^{\frac{-\lambda^2}{V} x} \; Cos \frac{\lambda}{\sqrt{V}} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (31)$$

Again, at

$$\left. \frac{\partial v_2}{\partial x} \right| \begin{array}{l} = \; 0, \; x \; = \; 0 \\ x = \; 0, \; B \end{array}$$

Equation (31) becomes

$$\frac{\partial v_2}{\partial x} = \frac{\lambda}{\sqrt{V}} v_o \, \ell^{\frac{-\lambda}{V} x} \; Sin \frac{\lambda}{\sqrt{V}} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \qquad (32)$$

i.e. $0 = -\dfrac{vo\lambda}{\sqrt{V}} \; Sin \dfrac{\lambda}{V} 0$

$vo\dfrac{\lambda}{V} \neq 0$ Considering NKP

Which is the substrate utilization for microbial growth (population) so that

$$0 = vo\frac{\lambda}{\sqrt{V}} \; Sin \frac{\lambda}{\sqrt{V}} B \qquad \ldots\ldots\ldots\ldots\ldots..\ldots\ldots\ldots \qquad (33)$$

$$\Rightarrow \frac{\lambda}{v} = \frac{n\pi}{2} n, 1, 2, 3 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (34)$$

$$\Rightarrow \lambda = \frac{\lambda}{V} = \frac{n\pi\sqrt{R}}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \qquad (35)$$

So that equation (31) becomes

$$\Rightarrow v_2 \;=\; vo\ell\,\frac{-n^2\pi^2R}{2}t\;Cos\frac{n\pi\sqrt{V}}{2\sqrt{V}}x \qquad \text{…………………………..} \qquad (36)$$

$$\Rightarrow v_2 \;=\; vo\ell\,\frac{-n^2\pi^2R}{2}x\;Cos\frac{n\pi}{2}x \qquad \text{…………………………..} \qquad (37)$$

Now, we consider equation (7), we have the same similar condition with respect to the behaviour

$$v\frac{\partial q_3}{\partial x} = -\theta\frac{\partial v}{\partial t} \qquad \text{……………………} \qquad (6)$$

$$v_3 \;=\; XT^1 \qquad \text{…………………………..} \qquad (38)$$

$$\frac{\partial v_3}{\partial x} \;=\; X^1T \qquad \text{…………………………..} \qquad (39)$$

i.e. $V\frac{\partial v_3}{\partial t} \;=\; XT^1$ ………………………….. (40)

Put (20) and (21) into (19), so that we have

$$VX^1T \;=-\,XT^1 \qquad \text{…………………………..} \qquad (41)$$

i.e. $V\frac{x^1}{x} \;-=\theta\frac{T^1}{T}$ ………………………….. (42)

$$V\frac{T^1}{T} + \lambda^2 \;=\; 0 \qquad \text{…………………………..} \qquad (43)$$

$$X^1 \;+\; -\frac{\lambda}{V}t \;=\; 0 \qquad \text{…………………………..} \qquad (44)$$

And $VT^1 + \lambda^2 t \;=\; 0$ ………………………….. (45)

Copyright © scitecpub.com, all rights reserved.

From (44), $x = ACos\frac{\lambda}{V}x + BSin\frac{\lambda}{\sqrt{V}}t$ ………………….. (46)

and (39) give

$$\boxed{T = C\,\ell\,\frac{-\lambda^{2}}{\theta}t} \qquad \text{…………………………..} \qquad (47)$$

By substituting (46) and (47) into (38), we get

$$\boxed{v_{3} = \left(ACos\frac{\lambda}{V}tx + BSin\frac{\lambda}{\sqrt{V}}t\right)C\,\ell\,\frac{-\lambda^{2}}{\theta}t} \qquad \text{………………} \qquad (48)$$

Subject equation (48) to conditions in (7), so that we have

$$vo = AC \qquad \text{…………………………..} \qquad (49)$$

Equation (49) becomes

$$v_{3} = vo\,\ell\,\frac{-\lambda^{2}}{\theta}t\ Cos\frac{\lambda}{V}t \qquad \text{…………………………..} \qquad (49)$$

Again, at $\left.\frac{\partial v_{3}}{\partial x}\right|_{\begin{array}{l} = 0 \quad t = 0 \\ t = 0, B \end{array}}$

Equation (50) becomes

$$\frac{\partial q_{3}}{\partial x} = \frac{\lambda}{V}Co\,\ell\,\frac{-\lambda}{\theta}t\ Sin\frac{\lambda}{V}t \qquad \text{……………………} \qquad (51)$$

Copyright © scitecpub.com, all rights reserved.

i.e. $0 = vo\frac{\lambda}{V} \;\; Sin\; \frac{\lambda}{V} 0$

$vo\frac{\lambda}{V} \neq 0$ Considering NKP again

Due to the rate of growth, which is known to be the substrate utilization of the microbes we have

$$0 = -vo\frac{\lambda}{\sqrt{V}} \;\; Sin\; \frac{\lambda}{\sqrt{V}} B \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (52)$$

The influence from substrate deposition were found in some regions of the formation, it express some constituents in penetrating unconfined beds, which are supposed to increase the population of virus in the system. But at this condition the physiochemical reaction of both parameters will determine the rate of microbial growth as it is expressed in equation (52) above. Such influence was considered based on stratification variation influenced by soil matrix that expressed degree of void ratio in the soil.

$$\Rightarrow \frac{\lambda}{V} = \frac{n\pi}{2} n, 1, 2, 3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (53)$$

$$\Rightarrow \lambda = \frac{n\pi\sqrt{V}}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (54)$$

So that equation (50) becomes

$$v_3 = vo\ell \; \frac{-n^2\pi^2 R}{2T} x \; Cos\frac{n\pi}{2} t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (55)$$

Now, we consider equation (8), we have

$$V \frac{\partial v_4}{\partial x} - \theta \frac{\partial v_4}{\partial x} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

Using Bernoulli’s method, we have

Copyright © scitecpub.com, all rights reserved.

$$v_4 = XT \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (56)$$

$$\frac{\partial v_4}{\partial x} = X^1 T \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (57)$$

$$\frac{\partial v_4}{\partial t} = X \ T^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (58)$$

Put (57) and (58) into (56), so that we have

$$VX^1T = -X \ T^1TX^1\theta \qquad \ldots\ldots\ldots\ldots\ldots \qquad (59)$$

i.e. $V\frac{X^1}{X} \quad - = \theta\frac{T^1}{T} \qquad \ldots\ldots\ldots\ldots\ldots \qquad (60)$

$$V\frac{X^1}{X} = \varphi \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (61)$$

$$\theta v\frac{T^1}{T} = \varphi \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (62)$$

$$X = A \ \ell \ \frac{\varphi}{V} x \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (63)$$

Put (62) and (63) into (56), gives

$$v_4 = A \ \ell \ \frac{\varphi}{T} \bullet B \ell \ \frac{-\varphi}{T} t \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (64)$$

$$v_4 = AB \ \ell^{(t-x)} \frac{\varphi}{T} \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (65)$$

Subject equation (66) to (8)

$$V_4 \ (o) = vo \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad (66)$$

Copyright © scitecpub.com, all rights reserved.

So that equation (67) becomes

$$\boxed{v_4 = Vo\,\ell^{(t-x)}\frac{\varphi}{\theta v}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (67)$$

Considering equation (10), we have

$$\phi\frac{\partial\ v_5}{\partial x} - Q\frac{\partial v^2{}_5}{\partial x^2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (10)$$

$$q_5 = X^{11}T \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (68)$$

$$\frac{\partial\ v_5}{\partial x} + X\ T^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (69)$$

$$\frac{\partial v_5}{\partial t} + X\ T^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (70)$$

Put (69) and (70), so that we have

$$\phi X^1 T - TX\ T^1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (71)$$

$$\phi\frac{X^{11}}{X}\theta - \theta\frac{T^1}{T} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (72)$$

$$\phi\frac{X}{X} = \varphi \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (73)$$

$$\theta\frac{T^1}{T} = \varphi \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (74)$$

Copyright © scitecpub.com, all rights reserved.

$$X^1 = A\ell\frac{\varphi}{\theta}t \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (75)$$

Put (74) and (75) into (68), gives

$$v_5 = A\ell\frac{\varphi}{\theta} \bullet B\ell\frac{-\varphi}{\theta}x \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (76)$$

$$v_5 = AB\ell^{(x-t)}\frac{\varphi}{\theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (77)$$

Subject (76) to (10)

$$v_5 \ (o) = vo \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (78)$$

So that equation (78) becomes

$$v_5 = vo\ell^{(x-x)}\frac{\varphi}{\theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (79)$$

Now, assuming that at the steady flow, there is no NKP for substrate utilization, our concentration here is zero, so that equation (79) becomes

$$v_5 = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (80)$$

The expression in equation (80) that consider when there is no NKP in the transport process implies that there is a tendency of degradation due to reaction of physiochemical parameters expressed in the study. Such development may generate degradation of virus if the microbes inhibit other physiochemical constituents in penetrating unconfined beds. In line with this condition, the expression in equation (8) develop an assumption stating that there is no substrate in some regions of the formation penetrating unconfined bed through the transport system.

Therefore, $C_1 + C_2 + C_3 + C_4 + C_5$ …………………. (81)

We now substitute (18), (37), (55), (67) into (81) so that we have the model of the form

Copyright © scitecpub.com, all rights reserved.

$$v \;=\; vo \;+ vo\ell\; \frac{-n^2\pi^2 Q}{2Q}\, x\; Cos \frac{n\pi Q}{2} t \bullet vo\ell\; \frac{-n^2\pi^2 Q}{2\theta}\, t\; Cos \frac{n\pi}{2} t \;+$$

$$qo\,\ell^{\,(t-x)}\frac{\varphi}{\theta} \qquad \text{…………………………..} \qquad (82)$$

$$\Rightarrow q \;=\; qo \;+1+\;\ell\; \frac{n^2\pi^2 Q}{2Q}\, x\; Cos \frac{n\pi}{2} \bullet Co\ell\; \frac{-n^2\pi^2 Q}{2\theta}\, t\; Cos \frac{n\pi}{2} t \;+$$

$$Co\,\ell^{\,(t-x)}\frac{\varphi}{\theta} \qquad \text{…………………………..} \qquad (83)$$

The expression in (83) is the final derived model that will monitor the deposition of ionic content and virus in penetrating unconfined beds. Such deltaic nature of the formation has generated lots of challenges in the strata penetrating unconfined bed. The derived solution expressed several challenging conditions found in the structural setting of Yenagoa metropolis. High degree of ionic content are found to deposit from natural origin, while virus is predominantly deposited from manmade activities through biological waste generation. The system expressed the paramount influence that results to migration of these two parameters to penetrating unconfined beds. The conditions were considered from the governing equation that was derived to develop the final model equation to (83).

4. Conclusion

Yenagoa Metropolis were confirmed to deposit high degree of ionic content and virus in penetrating unconfined bed, these pollution were confirmed through thorough investigation carried out on risk assessment of the formation. The study expressed results from the strata analysed to develop high ionic content and virus deposition, such evaluation could not monitor the rate of migration of these contaminants in soil and water environment. Ionic content and virus deposition are influenced by degree of saturation and high percentage of void ratio evaluated from risk assessment, this determine the degree of virus and ionic content in the soil. These factors are based on the geological setting of Yenagoa metropolis. Mathematical approach were found suitable to develop a baseline that experts can apply in preventing further migration of these two contaminants to unconfined beds. The derived solution from the governing equation considered several factors in developing the expressed model stated above.

Copyright © scitecpub.com, all rights reserved.

References

[1] U.S. EPA (1996a), Completed North American Innovative Remediation Technology Demonstration Projects, EPA-542-B-96-002, PB96-153-127, U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, August 12, Washington, D.

[2] Sposito, G. (1989), the Chemistry of Soils, Oxford University Press, New York.

[3] Evans, L.J. (1989), “Chemistry of Metal Retention by Soils, Environ. Sci. Tech., 23: 1046-1056.

[4] Cynthia R. E and David A. D 1997 Remediation of Metals-Contaminated Soils and Groundwater Carnegie Mellon University Department of Civil and Environmental Engineering Pittsburgh, PA

[5] Abdelouas, A., Lu, Y., Lutze,W., Nuttall, H.E., 1998. Reduction of U(VI) to U(IV) by indigenous bacteria in contaminated ground water. J. Contam. Hydrol. 35 (1–3), 217–233.

[6] Bernhard, G., Geipel, G., Brendler, V., Nitsche, H., 1996. Speciation of uranium in seepage waters of a mine tailing pile studied by time-resolved laser-induced fluorescence spectroscopy (TRLFS). Radiochim. Acta 74, 87–91.

[7] Bernhard, G., Geipel, G., Reich, T., Brendler, V., Amayri, S., Nitsche, H., 2001. Uranyl(VI) carbonate complex formation: validation of the Ca2 UO2 (CO3)_{3(aq)}species. Radiochim. Acta 89 (8), 511–518

[8] Brooks, S.C., Fredrickson, J.K., Carroll, S.L., Kennedy, D.W., Zachara, J.M., Plymale, A.E., Kelly, S.D. Kemner, K.M., Fendorf, S., 2003. Inhibition of bacterial U(VI) reduction by calcium. Environ. Sci. Technol. 37, 1850–1858.

[9] Ganesh, R., Robinson, K.G., Reed, G.D., Sayler, G.S., 1997. Reduction of hexavalent uranium from organic complexes by sulfate- and iron-reducing bacteria. Appl. Environ. Microbiol. 63 (11), 4385–4391.

[10] Gorby, Y.A., Lovley, D.R., 1992. Enzymatic uranium precipitation. Environ. Sci. Technol. 26 (1), 205–207.

[11] Lovley, D.R., Phillips, E.J.P., 1992a. Reduction of uranium by desulfovibrio desulfuricans. Appl. Environ Microbiol. 58 (3), 850–856.

[12] Lovley, D.R., Phillips, E.J.P., 1992b. Bioremediation of uranium contamination with enzymatic uranium reduction. Environ. Sci. Technol. 26 (11), 2228–2234.
93

[13] Lovley, D.R., Phillips, E.J.P., Gorby, Y.A., Landa, E.R., 1991. Microbial reduction of uranium. Nature 350 413–415.

[14] North, N.N., Dollhopf, S.L., Petrie, L., Istok, J.D., Balkwill, D.L., Kostka, J.E., 2004. Change in bacterial community structure during in situ biostimulation of subsurface sediment cocontaminated with uranium and nitrate. Appl. Environ. Microbiol. 70 (8), 4911–4920.

[15] Spear, J.R., Figueroa, L.A., Honeyman, B.D., 1999. Modeling the removal of uranium U(VI) from aqueous solutions in the presence of sulfate reducing bacteria. Environ. Sci. Technol. 33 (15), 2667–2675

[16] Waite, T.D., Davis, J.A., Payne, T.E.,Waychunas, G.A., Xu, N., 1994. Uranium(VI) adsorption to ferrihydrite: application of a surface complexation model. Geochim. Cosmochim. Acta 58, 5465–5478.

Copyright © scitecpub.com, all rights reserved.

[17] Wazne, M., Korfiatis, G.P., Meng, X.G., 2003. Carbonate effects on hexavalent uranium adsorption by iron oxyhydroxide. Environ. Sci. Technol. 37 (16), 3619–3624

[18] Wielinga, B., Bostick, B., Hansel, C.M., Rosenzweig, R.F., Fendorf, S., 2000. Inhibition of bacterially promoted uranium reduction: Ferric (hydr)oxides as competitive electron acceptors. Environ. Sci. Technol. 34 (11), 2190–2195
[19] Kalmykov, S.N., Choppin, G.R., 2000. Mixed Ca2/UO2/CO2 complex formation at different ionic strengths. Radiochim. Acta 88 (9–11), 603–606
.
[20] Liger, E., Charlet, L., Van Cappelin, P., 1999. Surface catalysis of uranium(VI) reduction by iro n(II). Geochim. Cosmochim. Acta 63, 2939–2955

[21] Truex, M.J., Peyton, B.M., Valentine, N.B., Gorby, Y.A., 1997. Kinetics of U(VI) reduction by a dissimilatory Fe(III)- reducing bacterium under non-growth conditions. Biotechnol. Bioeng. 55 (3), 490–496. 94

[22] **Eluozo, S. N.**Mathematical model to monitor the rate of dissolved uranium influenced by void ratio and linear velocity in homogeneous coarse sand in Elele, rivers state of Nigeria International Journal of Waste Management and Technology Vol. 1, No. 6, September 2013, PP: 87 -94

Copyright © scitecpub.com, all rights reserved.